

## Static Stretching of the Hamstring Muscle for Injury Prevention in Football Codes: a Systematic Review

Slavko Rogan<sup>\*1,2ABCDEG</sup>, MSc, PT; Dirk Wüst<sup>3DEG</sup>, PT; Thomas Schwitter<sup>4ABCG</sup>, BSc, PT;  
Dietmar Schmidtbleicher<sup>5DEG</sup>, PhD

### Authors' Affiliation:

1. Bern University of Applied Sciences, Health, Bern, Switzerland
2. AfiPT, Akademie für integrative Physiotherapie und Trainingslehre, Grenzach-Wyhlen, Germany
3. Football Club Basel, Basel, Switzerland
4. University of Physiotherapy, Thim van der Laan, Landquart, Switzerland
5. Goethe-University, Institute of Sport Sciences, Frankfurt/Main, Germany

### Authors' Contribution

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- C** Data Analysis / Interpretation
- D** Manuscript Preparation
- E** Critical Revision of the Manuscript
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### \* Corresponding Author:

Address: Slavko Rogan, Murtenstrasse 10, 3008 Bern, Switzerland

E-mail: slavko.rogan@bfh.ch

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### Abstract

**Purpose:** Hamstring injuries are common among football players. There is still disagreement regarding prevention. The aim of this review is to determine whether static stretching reduces hamstring injuries in football codes.

**Methods:** A systematic literature search was conducted on the online databases PubMed, PEDro, Cochrane, Web of Science, Bisp and Clinical Trial register. Study results were presented descriptively and the quality of the studies assessed were based on Cochrane's 'risk of bias' tool.

**Results:** The review identified 35 studies, including four analysis studies. These studies show deficiencies in the quality of study designs.

**Conclusion:** The study protocols are varied in terms of the length of intervention and follow-up. No RCT studies are available, however, RCT studies should be conducted in the near future.

**Key Words:** American Football; Soccer; Prevention of Muscle Lesion; Flexibility

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## INTRODUCTION

In stop-and-go sports like soccer, Australian Rules football, rugby or football, hamstring muscle injuries are the most common injuries [1-10]. The German "Fussball Bundesliga" describes muscle strains, muscle tears or muscular tendon problems in the hamstring muscles as types of injury [11]. In American football 41% of all injuries are hamstring muscle injuries [12], and in Australian Rules football, the prevalence is estimated to be 16% [13]. Hamstring strains are the third most common injury, following knee and ankle injuries in Division 1 soccer teams [14]. Woods et al [15] describes that 12% of professional soccer players injuries are hamstring strains, and the financial burden of this is estimated to be £74.7 million. Hamstring muscle injuries usually cause significant time loss from competition and training [3,16]. The incidence of

hamstring injuries is estimated at approximately 6 players per season with each injured player missing three matches per season [3].

Understanding the biomechanical factors of hamstring injury are crucial for the development of preventative strategies. Most hamstring injuries happen while running during the terminal swing phase of the running cycle [17,18]. EMG and Kinetic studies reveal that the hamstrings are most active and develop the greatest torques at the hip and knee during the late swing phase of running [19,20]. At the end of the swing phase, the hamstring muscle undergoes an eccentric contraction and absorbs energy from the swing limb before foot contact [21,22]. During this phase the hamstring muscles are stretched while facing eccentric contraction load [23] and perform the greatest amount of negative work during this time [24]. During these running cycle phases the hamstrings are under the

greatest pressure and injury is likely to occur [19,25]. Heiderscheit et al [26] research shows the exact moment of a hamstring injury while running on a treadmill. The injury occurs during a 130 ms period in the late swing phase of gait. During this phase the hamstring reached a muscle length that was 12% longer than the length seen while standing.

The high injury rate having a negative effect on a team's success is a controversial issue in the media [27]. However, this is not the only reason to focus on injury prevention. The prevention of hamstring injuries is a key priority for all stop-and-go activities in sports due to the high recurrence rate of 34% in the same season [3,4].

Reduced flexibility is a risk factor in muscle strain injury [28,29]. Treatment for improving flexibility has been used since the 1980s by physiotherapists, athletes and coaches: the stretching technique. Mc Hugh and Cosgrave [30] stated a reduction of muscle injuries was shown when stretching was performed. Wiemann and Kamphöfner [31] postulated that long-term stretching can be used to prevent injury. The Pope et al [32] study showed no effects after stretching was performed.

Other brief reviews about stretching literature exist [33]. Some authors describe stretching as an important part of an injury prevention programme, although these conclusions are not based on any clinical evidence [34-37]. Shrier [38] and Yeung [39] postulate that pre-exercise stretching does not reduce the incidence of local muscle injury [39]. Shrier [38] summarizes in his review that stretching exercises are not effective for prevention of musculoskeletal injuries in the lower extremities.

The majority of studies on stretching techniques found in the literature focus on the stretching method. Static and dynamic stretching are both summarized under the term "stretching". Static stretching is a method where a point of tension is reached and maintained. Dynamic stretching involves rhythmic, repetitive movements or swings [40]. This review focuses on static stretching.

The literature shows no specific information about the prevention in sports injuries. One reason is the poor quality of the studies and reviews. Another reason is that no study focuses on the effect of stretching of one muscle group and one sport. This review will evaluate and focus on the hamstrings. This muscle group has the

highest strain injury rate in stop-and-go sports like football codes.

This review will use currently available evidence to evaluate the effects of static stretching as prevention of hamstring injuries in football codes.

## METHODS AND SUBJECTS

### *Data sources and searches:*

This systematic review follows the PRISMA guidelines [41,42]. A literature search of electronic databases was performed until September 2012, using PubMed, Cochrane Register of Controlled Trials, Physiotherapy Evidence Database (PEDro), Web of Science and Bisp-Datenbank (SPOLIT, SPORFOR, SPOMEDIA). The unpublished International Clinical Trials Registry Platform from the World Health Organization (WHO) was also searched. Furthermore, a manual search was performed using the reference lists of retrieved publications.

This systematic review was conducted to answer the review question formulated according to recommendations from the PICO-model. The acronym PICO stands for Population (in the actual review: soccer-football-rugby players), Intervention (static stretching of the hamstring muscle), Comparator (athlete with intervention programme and without intervention programme and Outcomes (range of motion as injury prevention, static stretching as injury prevention) [43].

Using the PICO reporting system, a combination of medical subject headings (MeSH) and text words as search terms, the search strategy of this review was formulated as follows:

Population: soccer player, football player, professional players, college football player.

Intervention: static stretching, stretching.

Outcome: range of motion, flexibility, injury, prevention, risk, strain, effectiveness.

Two independent reviewers (SR, TS) screened the titles and abstracts for eligibility. The following inclusion and exclusion criteria were defined for the studies reviewed: In the literature study, no emphasis

was placed on gender. No restriction to any age-group. The athletes had no physical limitations; they could perform their sport. The randomized controlled trials (RCT) and nonrandomized controlled trials which (NRCT) have been published within the last 20 years. Both published and unpublished (grey literature) full text articles in English or German, were eligible for inclusion.

#### Data Extraction and quality assessment:

The methodological quality of the included articles was rated with the “Cochrane Collaboration tool for assessing risk of bias”. The criteria list comprised of six items. Each item was marked with “+” if the criterion was met, with “-” if the criterion was not met, and with “?” if the information was not provided or ambiguous. All papers included were scored independently by two reviewers (SR, TS). Disagreements between the reviewers were resolved by consensus. If consensus was not found, the third reviewer (DW) made the final decision.

In addition, general characteristics of the studies were extracted. Two authors (SR, TS) independently abstracted the following information from each of the studies which are included in this review:

1) design; 2) subjects or club; 3) period of intervention;

4) intervention protocol; and 5) outcome measurement.

Due to unavailable data, an analysis to estimate the individual and pooled effect sizes and 95% CI could not be conducted.

## RESULTS

The literature search generated 35 possible studies (Pubmed n=286, Cochrane n=79, PEDro n=7, Web of science n=38, Bisp n=91 and WHO International Clinical Trials Registry Platform n = 1).

35 studies were selected. 14 studies were discarded after reviewing the title and the abstracts, because they did not meet the inclusion criteria. Studies that were not available as full text in databases were obtained via e-mail from the authors. 21 full text articles were further analysed. They were read and examined for relevance. 9 studies were not relevant and were excluded. Twelve full text articles were read in more detail. A further eight studies were excluded. They did not refer to hamstring muscles, or football codes. Finally, four articles from the literature search were included (Fig. 1).

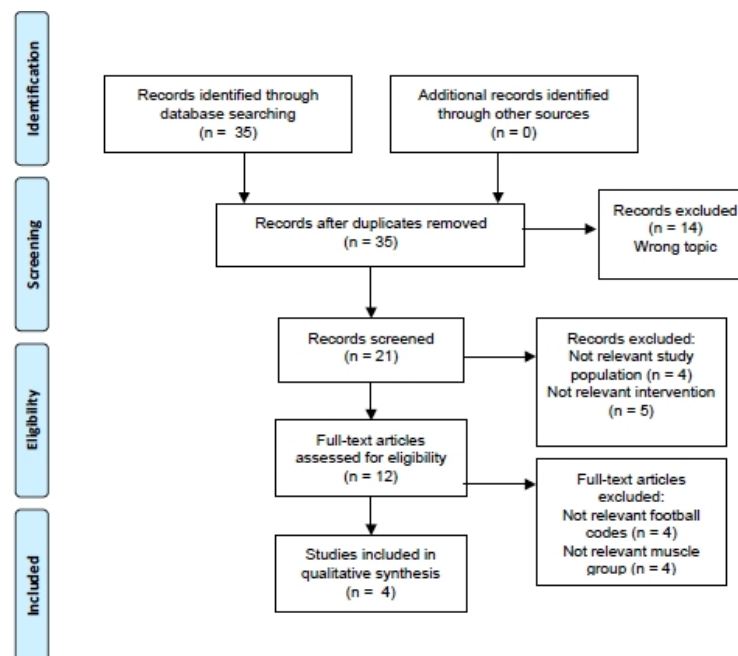


Fig. 1: Flow of studies through the review process

**Table 1:** Summary methodological quality (Risk of Bias)

Study	Allocation concealment	Blinding	Incomplete outcome data	Selective outcome reporting	Free for other bias
Arnason et al (2008) [2]	-	-	+	+	+/-
Cross and Worrell (1999) [12]	-	-	+	+	+
Dadebo et al (2003) [1]	-	-	+	+	+/-
Verrall et al (2005) [44]	-	-	+	+	+/-

+: yes; -: no; +/-: unclear

### Methodological quality:

Cross & Worrell [12] research is considered as the highest quality paper among the included studies. However, all studies included in table 1 show a bias following the “Cochrane Collaboration tool for assessing risk of bias”.

Table 1 illustrates that no study has adequately investigated “Allocation concealment”. It is therefore not possible for researchers to know the treatment allocated to the participant before entering the study, which represents a high risk of bias. In addition, the group classification of subjects and investigators is predictable.

No study was “blinded”. Blinding was not possible because the medical department passed on the information to the examiner about the hamstring injuries.

In each study, the items “incomplete outcome data” and “selective outcome reporting” were positively rated. Exclusion of subjects from the study was established and all results announced in the method were discussed. In the four studies it is unclear whether other sources of bias were apparent.

Table 1 shows the overview of the risk of bias analysis of all studies.

### Study characteristics:

Table 2 shows the characteristics of the included studies. The studies included are one from Australia, England, Iceland, Sweden and the United States. A sample of 265 football players and 60 football teams was covered. The studies were published between 1999 and 2008.

### Intervention Protocol:

Five studies [1,12,44,45] had an active static stretching intervention programme. Verrall et al’s investigation

[44] added interventions like PNF stretching, sport specific training and anaerobic training.

Dadebo et al [1] conducted flexibility training with active static stretching during football training sessions; however, strength training and endurance training modalities were also included. These studies ranged from two [1,12] to four years [44].

Bixler and Jones [45] conducted one session; static stretching for 90 seconds during half-time over one football season.

The duration of each individual stretching exercise varied from study to study; they were generally for 15 to 30 seconds and repeated at least three times per leg. The subjects performed these stretching exercises three to five times a week [1,12,44].

Arnason et al [2] was the exception regarding stretching technique and the period of investigation. The intervention group performed tension-relaxation stretching (TRS) during warm-up with a break of 20 seconds. Flexibility training TRS was also performed, with 45-second stretches. These exercises were performed three times a week, each with three repetitions per side after training. This study extended for over four years, with the strength-training program.

In the prospective studies by Cross and Worrell [12] and Verrall et al [44], the breach rate of hamstring muscles was determined by questionnaire. For one [12] or two years [44] respectively, the athletes performed no specific training or undertook a static stretching programme. Subsequently, static stretching intervention in football players was conducted. The occurrence of hamstring injuries during the period with no intervention and the period with intervention were compared.

Arnason et al [2] conducted a retrospective study with football players. They compared an intervention group with a control group. Data extraction was through interviews. Participants completed an injury

**Table 2:** Study characteristics of the included studies

Study	Design	No subjects or club	Period of intervention	Intervention protocol	Outcome measurement
<b>Arnason et al (2008)</b> [2]	Experimental design	30 soccer teams	4 years	All two groups performed a partner contract-relax stretching over 45sec static stretch during 2001, one group performed additional eccentric strength in 2001 and 2002, one group performed additional eccentric strength training 2001	No effects on hamstrings injury - (relative risk: 1.53, $P=0.2$ )
<b>Cross &amp; Worrell (1999)</b> [12]	Retrospective	195 players	2 years	Year one no stretching Year two (1995) incorporated a 3 times over 15sec static stretching program	Muscle and tendon strains decrease about 48% ( $P<0.05$ )
<b>Dadebo et al (2003)</b> [1]	Qualitative study	30 soccer teams	2 years	Questionnaire data on flexibility methods and Hamstring strain rates were collected	Flexibility training correlates with a decreased injury rate ( $-0.53$ ; $P=0.01$ )
<b>Verrall et al (2005)</b> [44]	Experimental design	70 players	4 years	Year one and two no stretching Year three and four 15 sec static stretching in varying degrees of knee flexion ( $0^\circ$ , $10^\circ$ , $90^\circ$ )	Hamstring strains incidence decrease in matches ( $P=0.01$ )

protocol during the study period.

Dadebo et al. [1] studied the flexibility training protocols of 30 English football teams. The objective was to determine the current protocols, and whether there was a correlation between flexibility training and the “Hamstring strain rate” (HSR) using “Pearson’s” or investigate “Spearman’s rank order test”.

#### **Outcome measurement:**

In Dadebo et al. [1] and Arnason et al. [2] one player was injured during the game or training, resulting in pain in the hamstring muscles and prohibiting from any further training sessions or games. Furthermore, hamstring injuries were classified into three grades. Grade 1 was classified as a minor injury with complete but painful contraction. Grade 2 was classified as a moderate injury with partial rupture and abnormal contraction, and grade 3 indicating a complete rupture with impossible contraction.

Verrall et al [44] defined ‘games missed’ due to injuries and posterior leg pain, although direct contact with the leg as the cause of the injury were excluded. This definition meets that of the Australian Football League (AFL). Cross and Worrell’s study shows [12] players were hurt if they had an impairment lasting at least one day.

All studies reported the methods used to diagnose injuries. The incidence of hamstring injuries was

determined in a clinical examination by a medical professional. The diagnoses were made by team doctors [1,44], MRI radiologists [44], medical staff [2], or the coaches [12]. All the studies expressed failure rate as missed hours per season or the number of injured players caused by hamstring injuries.

In conjunction with other measures such as eccentric strength training [2], anaerobic and sport-specific training [44] and cardio and strength training [1] the remaining studies also found a reduction of hamstring injuries.

## **DISCUSSION**

Scientific analyses are considerable for providing scientific evidence for static stretching intervention. Few studies with low qualitative and quantitative characteristics have been published over the last decades. It is therefore not possible to undergo research documentation concerning the effects of static stretching on prevention of hamstring injuries. But where randomized clinical trials are lacking, it would be irrational to ignore the potential of gathering information from other sources [46].

In contrast to this review, Weldon and Hill [33]

included four RCTs. They postulated that stretching does not reduce the incidence of muscle strain injuries. For non RCT they showed a reduction of injuries after stretching. However, the focus was not, as in this review, on one sport and muscle group. Therefore, it is recommended that reviews be reported clearly, adhering to a plan showing the research, the findings and what conclusions were drawn. Recommendations provided by the PRISMA guidelines, on reporting of research, can improve reporting quality. This has not been carried out by Weldon and Hill [33].

In 1983 Ekstrand et al [47] evaluated the effectiveness of a multi-factorial program to reduce injury in male soccer players. In this randomized controlled trial, 180 players were randomly assigned to an intervention (n=90) or control group (n=90) group. One part of this seven-part-preventive program was a 10 minute stretching exercise of the hamstring, quadriceps and adductor muscles. This study shows positive effects after a 6 months. Seventy-five percent fewer injuries occurred. This review reveals that if stretching is embedded in a warm-up program, the injury rate is reduced. Cross and Worrell [12] found that muscle injuries of the lower extremities were reduced after static stretching programs. This study aimed to improve the mobility by means of static stretching in American football players, because mobility limitation is one of the primary factors for muscle tendon injury.

No study measured movement, which prevents assessing the association between expansion flexibility and the injury risk. Many factors are responsible for this reduction. Because of their study designs, it was not possible to demonstrate a relationship between cause and effect, and therefore the reason for the positive effect of stretching can not be explained. Ekstrand et al [47] and Cross and Worrel [12] studies was not only limited to hamstring muscles, but also covered the quadriceps, hip adductors and calf muscles.

Dadebo et al [1] described after static stretching in combination with other interventions a standardized stretching protocol correlated with a reduced hamstring injury rate. The flexibility training of the hamstring muscles is likely to improve the mobility of footballer players thus preventing injuries. The study supports the assumption that a proper stretching protocol with football players can prevent hamstring injuries. A

constant application of 15-30 seconds, as described in the literature [1,48] may be the key to success. Stretching techniques should be static or PNF stretching.

Dadebo et al [1] described not clearly, the effects of the involved strength and endurance trainings on the reduction of hamstring injuries. Stretching exercises are not the only factor for few fewer muscle injuries because hamstring injuries are more complex and multifactorial [1]. In addition, the Dadebo et al [1] study notes all clubs did not participate and the results of the study would have been more accurate if more players participated.

The findings from Dadebo et al [1] are consistent with Verral et al [44]. They explain that a specific intervention program results in a significant reduction of hamstring injuries in Australian football players. The stretching exercises are performed in the after-training stage. Tired muscles are more prone to injury compared to muscles that are not exhausted because they absorb less energy. For this reason, the flexibility training helps prevent injuries in tired muscles. They also argue that by virtue of extension muscle power, consumption is improved. This makes muscles more resistant to injury. This is due to the muscle's visco-elastic properties, which can be positively changed through stretching.

Verral et al [44] points out that the effect of static stretching on preventing hamstring injuries is not clear. "Anaerobic interval training" was conducted with static stretching; which, however, does not allow for a clear understanding as to whether stretching is responsible for this result. Furthermore, the participants performance of the exercises cannot be checked. The small number of football players studied was another limitation.

In contrast to the other studies, Arnason et al [2] concluded that the hamstring muscle flexibility training has no effect on football players risk of injury to the muscle group. Most hamstring injuries occur during sprints, when the muscle performs the most eccentric muscle work. Flexibility training combined with warm-up stretching therefore has no influence on minimizing hamstring injuries, since during a sprint, the maximum muscle length is never exhausted and therefore the hamstring muscles are not completely stretched. In the sprint phase, the force pressure on the muscle is the

determining factor. A positive effect can be recorded if warm-up stretching is combined with eccentric strength training.

In general, it was not to be expected that stretching has a positive effect on the decrease of the hamstring injury rate; because some studies in non-football players show no effects. Only Arnason et al [2] found no effects.

**Limitation:** Interpretations of the presented studies' evaluations influence the explanatory power. Due the heterogeneity of the intervention methods the data was inconclusive. For this reason an analysis to estimate the individual and pooled effect sizes and 95% CI could not be conducted.

Other limitations of this systematic literature search are discussed.

1) All four studies which investigated power sports such as football and soccer and static stretching to prevent hamstring muscle injuries, showed a low level of evidence [1,2,12,44]. There are no RCTs but exclusively NRCTs. To achieve a higher level of evidence, RCT studies should be conducted in the future.

2) The results of the explanatory power of the four studies were presented using the "risk of bias form". They show that the four studies represent a lack of evidence. The group allocation was predictable for both participants and researchers of the studies. In addition, there was no blinding, which means that the examiner knew the study's measurement results and had a previous knowledge regardless of the study interventions.

3) Only one study focused solely on static stretching, while the remaining studies undertook additional interventions. It is therefore not possible to draw a clear conclusion on whether stretching is responsible for the achieved results.

4) The definition of injury is a key parameter in this review and the comparisons between the studies. A soccer or football player is injured when he can no longer perform this sport. The four studies show heterogeneous definitions. In Cross and Worrell [12] players were injured if they had an impairment of at least one day; meanwhile in Verrall et al [44] posterior leg pain predominated, although direct contact with the leg as the cause of the injury was excluded. An MRI was used in each case to determine the injury. In

addition, Dadebo et al [1] classified hamstring injuries into three categories. Grade I: minor injury with painful contraction; Grade II: moderate, partial tear with abnormal contraction and Grade III: complete tear with weak to non-existent contraction. According Arnason et al [2], a player is considered injured when they could not engage in any sport due to "pain in the hamstrings". In the future, a uniform standardized definition of injury should be defined enabling research to be more congruent. If all researchers proceed the same way, using the same classification of injuries, results can be discussed and presented accordingly. Why a uniform definition does not exist is not explained in any of these studies. One reason could be, however, that the studies have different conditions when diagnosing an injury, for example if a doctor is available to make the diagnosis or what medical aids are used. The term "muscle length" is another definition that causes confusion in the literature. The length of the hamstring muscle length is in fact not the length of the muscle, but the strain tolerance of the individual [49].

5) There are customized stretching protocols that achieve improved flexibility. However, to date, there are no values on how an optimal flexibility of use can serve as a prevention of hamstring injuries. That is why the stretching protocols were applied in different ways in the studies reviewed.

6) In the reviewed studies, the duration of an exercise was limited to 15-45 seconds. McHugh and Cosgrave [30] discussed how long a stretching position should be held to achieve a decrease in muscle stiffness, concluding that only a stretching position held for 5 x 60 or 4 x 90 seconds would work. They also postulate that static stretching of the hamstring muscles of two times over 45 seconds has no significant effect with regard to the passive resistance to stretching [30].

7) In the studies, static stretching was performed at different points, either during warm-up [1,2] or during [44] or after exercise [1,2,12,44]. It was not established if stretching during the warm-up reduced muscle injuries or not.

8) Hamstring injuries require a long recovery time and have a high recurrence rate [1]. Mueller-Wohlfahrt [50] illustrates that 13% of hamstring injuries recur. In addition, the down time in case of injury recurrence is

up to 30 percent longer than with a first injury. Extensive study has not been undertaken to indicate if a player with a previous hamstring injury is more vulnerable to reinjury. A player's history should also be considered when conducting research.

9) Only Dadebo et al<sup>[1]</sup> have differentiated at which time a hamstring can injury occur. They showed that 74 out of 122 hamstring strains occur towards the end of the game or training session. A player's fatigue may be considered a factor as well. The authors also pointed out that external factors may have affected the results.

10) Due to missing data, an analysis to estimate the individual and pooled effect sizes and 95% CI could not be conducted.

## CONCLUSION

Studies with low qualitative and quantitative characteristics have been published over the last decades. It is therefore not possible to find documentation concerning the effects of static stretching on prevention of hamstring injuries. Furthermore, the study protocols are diverse, both regarding intervention duration and follow-up. Since no RCT studies are available, they should be conducted in the near future.

**Conflict of interests:** None

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